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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
09/255,856	02/23/99	IWASAKI	T 501.39631X00

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MMC1/1211

EXAMINER

SMOOT, S

ART UNIT

PAPER NUMBER

2813

DATE MAILED:

12/11/00

**Please find below and/or attached an Office communication concerning this application or proceeding.**

**Commissioner of Patents and Trademarks**

<b>Office Action Summary</b>	Application No. 09/255,856	Applicant(s) IWASAKI ET AL.	
	Examiner Stephen W. Smoot	Art Unit 2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 13 November 2000.
- 2a) ☒ This action is FINAL.                      2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-6 and 8-29 is/are pending in the application.  
     4a) Of the above claim(s) 8 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-6 and 9-29 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claims \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are objected to by the Examiner.
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved.
- 12) ☐ The oath or declaration is objected to by the Examiner.

**Priority under 35 U.S.C. § 119**

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).  
     a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. & 119(e).

**Attachment(s)**

- |   |  |
|---|--|
| 15) <input type="checkbox"/> Notice of References Cited (PTO-892)                             | 18) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s). _____  |
| 16) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)         | 19) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 17) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ | 20) <input type="checkbox"/> Other:  |

## **DETAILED ACTION**

### ***Election/Restrictions***

1. This application contains claim 8 drawn to an invention nonelected with traverse in Paper No. 6. A complete reply to the final rejection must include cancelation of nonelected claims or other appropriate action (37 CFR 1.144) See MPEP § 821.01.

### ***Claim Objections***

2. Claim 28 is objected to because of the following informality: In line 3 of claim 28, delete "or platinum". Appropriate correction is required.

### ***Claim Rejections - 35 USC § 112***

3. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claim 6 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

In claim 6, the Applicant does not particularly point out how both the first diffusion layer and the second diffusion are in contact with the plug and also in contact with each other (see lines 4-7 of claim 6).

***Claim Rejections - 35 USC § 102***

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –  
(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

6. Claims 9-10, 16-17, 21-22, 24-27 are rejected under 35 U.S.C. 102(e) as being anticipated by Schacam-Diamand et al.

Referring to Fig. 13 of Schacam-Diamand et al., a metal line structure overlying a wafer substrate (see column 4, lines 41-44) is disclosed with the following features: (a) copper interconnects (33) in contact with a catalytic seed layer; (b) the catalytic seed layer (18a) can be comprised of platinum or rhodium (see column 7, lines 28-31); (c) a diffusion barrier layer (17a) that can be comprised of titanium nitride, tantalum or tungsten (see column 6, lines 35-37 and column 7, lines 26-28); and (d) the catalytic seed layer and diffusion barrier layer are in contact. These are limitations set forth in the independent claims 9, 27 and the further limitations to claim 9 set forth in the dependent claims 10, 16-17, 21.

Now referring to Fig. 20 of Schacam-Diamand et al., a structure is disclosed (see column 10, lines 26-33) with three metal lines (52) that are electrically connected by plugs (51). These are the further limitations to claim 9 set forth in claim 22. By using the above metal line structure of Fig. 13 to form two adjacent metal lines in Fig. 20, the further limitations to claim 22 set forth in claims 24-26 are anticipated.

7. Claims 11-12 are rejected under 35 U.S.C. 102(b) as being anticipated by Woo et al.

Woo et al. disclose a platinum film (see column 5, lines 4-9) formed on a semiconductor substrate (see column 4, lines 48-51) with intermediate layers that can include ruthenium, iridium, osmium, or rhodium for adhesion (see column 4, lines 48-51) or titanium nitride as a diffusion barrier layer (see column 4, lines 40-48). These are the limitations set forth in the independent claim 9 and the further limitations to claim 9 set forth in claims 11-12.

### ***Claim Rejections - 35 USC § 103***

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

9. Claims 1-3 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hussein et al. in view of the IBM Technical Disclosure Bulletin.

Referring to Fig. 3, Hussein et al. disclose the following limitations set forth in claims 1-3: a semiconductor substrate (1), a diffusion barrier (5), and interconnect layers (7, 32) that can be copper (see column 3, lines 50-53). However, Hussein et al. do not disclose ruthenium as a diffusion barrier material. The IBM Technical Disclosure Bulletin does teach that ruthenium (as well as rhenium, osmium, and iridium) is an exceptional barrier against the diffusion of copper (see first sentence of final paragraph). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the teachings of the IBM Technical Disclosure Bulletin with those of Hussein et al. and use ruthenium as a diffusion barrier material. Hussein et al. recognize that copper diffusion into silicon and, also into any surrounding dielectric material, can result in defective circuitry (see column 1, lines 55-57).

**Response to Arguments:** Applicant's arguments filed on 13 November 2000 (Paper No. 10, pages 15-17) have been fully considered but they are not persuasive. The above rejection of claims 1-3 is based on the fact that at the time of the applicant's invention, a person of ordinary skill in the art would have known from the IBM Technical Disclosure Bulletin that ruthenium could be used as a copper diffusion barrier material and would have been motivated to use it as the diffusion barrier in the interconnect structure disclosed by Hussein et al.

Regarding the process limitations of claims 1-3, as previously stated in Paragraph 1 of Paper No. 8, the process limitations of device (or structure) claims are

generally not given any patentable weight (see MPEP section 2113). Furthermore, it has been held that in order for product-by-process claims to be patentable, the product must be novel, useful, and unobvious [see *In re Brown and Saffer*, 173 USPQ 685 (CCPA 1972)].

In response to applicant's argument that a barrier against diffusion is different from avoiding electromigration, the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

10. Claims 4-5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Schacham-Diamand et al. in view of the IBM Technical Disclosure Bulletin.

Referring to Fig. 20, Schacham-Diamand et al. disclose a structure with the following limitations of claims 4-5: a semiconductor substrate (54), copper interconnections (52), and plugs or vias (51). They also disclose the use of a diffusion barrier in contact with the copper interconnect (see column 3, lines 31-33) which is a limitation of claim 5.

However, Schacham-Diamand et al. do not disclose the limitation of claim 4 wherein at least one layer of the plug is selected from the group consisting of rhodium, ruthenium, iridium, osmium, and platinum. They also do not disclose the use of ruthenium as the material for forming the diffusion barrier and the plug (both limitations of claim 5).

The IBM Technical Disclosure Bulletin does teach that ruthenium (as well as rhenium, osmium, and iridium) is an exceptional barrier against the diffusion of copper (see first sentence of final paragraph).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the teachings of the IBM Technical Disclosure Bulletin with those of Schacham-Diamand et al. and form a plug per claim 4 having at least one layer of ruthenium, iridium, or osmium in order to prohibit the diffusion of copper into the plug. It also would have been obvious to one of ordinary skill in the art at the time the invention was made to combine these teachings and use ruthenium as both the plug material and the diffusion barrier material per claim 5.

Schacham-Diamand et al. recognize that, in addition to the copper-dielectric interface, the use of diffusion barrier material to encapsulate copper is also necessary at the interfaces of copper with other metals (see column 2, lines 18-21). The interface of the copper interconnect and plug of claims 4-5 is an example of such an interface. In light of the IBM Technical Disclosure Bulletin, see page 215, a person of ordinary skill in the art would have been motivated to use ruthenium, iridium, or osmium metals due to their exceptional resistance against the diffusion of copper.

**Response to Arguments:** Applicant's arguments filed on 13 November 2000 (Paper No. 10, pages 17-18) have been fully considered but they are not persuasive. The above rejection of claims 4-5 is based on the fact that at the time of the applicant's invention, a person of ordinary skill in the art would have known from the IBM Technical Disclosure Bulletin that ruthenium (as well as osmium or iridium) could be used as a

copper diffusion barrier material and would have been motivated to substitute it for the diffusion barrier in the interconnect structure disclosed by Schacham-Diamand et al.

Regarding the process limitations of claims 4-5, as previously stated in Paragraph 1 of Paper No. 8, the process limitations of device (or structure) claims are generally not given any patentable weight (see MPEP section 2113). Furthermore, it has been held that in order for product-by-process claims to be patentable, the product must be novel, useful, and unobvious [see *In re Brown and Saffer*, 173 USPQ 685 (CCPA 1972)].

In response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., the neighboring layer – see Paper No. 10, middle of page 18) are not recited in the rejected claims 4-5. Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993).

11. Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Schacham-Diamand et al. and the IBM Technical Disclosure Bulletin as applied to claim 5 above, and further in view of Woo et al.

Although written in independent form, claim 6 has all of the limitations of claim 5 plus a second diffusion barrier, formed of titanium nitride, in contact with the ruthenium diffusion barrier and the ruthenium plug. So, Schacham-Diamand et al. and the IBM Technical Disclosure Bulletin disclose all of the limitations of claim 6 except for the use

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of a second diffusion barrier. Woo et al. teach that the use of titanium nitride (TiN) layers can perform other functions besides that of diffusion barrier such as improved adhesion between substrate and metal or between metal and dielectric (see column 4, lines 48-51). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the TiN adhesion layer taught by Woo et al. in conjunction with the teachings of Schacham-Diamand et al. and the IBM Technical Disclosure Bulletin in order to obtain improved adherence to the substrate and/or the dielectric.

**Response to Arguments:** Applicant's arguments filed on 13 November 2000 (Paper No. 10, pages 18-19) have been fully considered but they are not persuasive. The above rejection of claim 6 is based on the fact that at the time of the applicant's invention, a person of ordinary skill in the art would have known from the IBM Technical Disclosure Bulletin that ruthenium could be used as a copper diffusion barrier material and would have been motivated to use it as the diffusion barrier in the interconnect structure disclosed by Schacham-Diamand et al. The same person at the same time would have been further motivated to form additional layers such as a titanium nitride layer for improved adhesion as suggested by Woo et al. The applicant does make the point that Woo et al. is primarily concerned with platinum films (see Paper No. 10, page 19, line 4). However, Woo et al. do suggest that copper may be used as a conductive plug layer (see column 4, lines 34-40), which would indicate that the adhesive property of titanium nitride would be an advantage for other metal films besides platinum.

Regarding the process limitations of claim 6, as previously stated in Paragraph 1 of Paper No. 8, the process limitations of device (or structure) claims are generally not given any patentable weight (see MPEP section 2113). Furthermore, it has been held that in order for product-by-process claims to be patentable, the product must be novel, useful, and unobvious [see *In re Brown and Saffer*, 173 USPQ 685 (CCPA 1972)].

12. Claim 28 is rejected under 35 U.S.C. 103(a) as being unpatentable over Schacham-Diamand et al. as applied to claim 27 above, and further in view of Zhao et al and the IBM Technical Disclosure Bulletin.

As shown above, Schacham-Diamand et al. anticipate the independent claim 27. However, they do not disclose the further limitations to claim 27 set forth in claim 28, which is that another neighboring film of rhodium, ruthenium, iridium, osmium, or platinum is formed on the opposite side of the copper film. Zhao et al. teach the formation of barrier layers (13 and 24 in Fig. 6) above and below a copper plug (23 in Fig. 6 – also see column 8, lines 37-42) and the IBM Technical Disclosure Bulletin teaches that ruthenium (as well as rhenium, osmium, and iridium) is an exceptional barrier against the diffusion of copper (see first sentence of final paragraph).

Therefore it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the interconnection structure of Schacham-Diamand et al. by incorporating the teachings of Zhao et al. and the IBM Technical Disclosure Bulletin to form a second rhodium, ruthenium, iridium, osmium, or platinum film in order to inhibit copper diffusion.

13. Claims 13-15, 18-20, 23, 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Schacham-Diamand et al., Woo et al., Zhao et al., and the IBM Technical Disclosure Bulletin as applied to claims 11, 16, 22, 28 above.

The further limitations to claim 11 set forth in claims 13-15, to claim 16 set forth in claims 18-20, to claim 22 set forth in claim 23, and to claim 28 set forth in claim 29 are process limitations. Claims 13-15, 16-18, 23, 29 are prima facie obvious since it has been held that in order for product-by-process claims to be patentable, the product must be novel, useful, and unobvious [see *In re Brown and Saffer*, 173 USPQ 685 (CCPA 1972)].

### ***Conclusion***

14. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

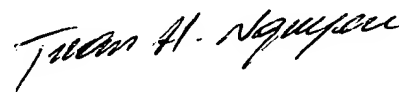
A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of

the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

15. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Stephen W. Smoot whose telephone number is 703-305-0168. The examiner can normally be reached on M-F (8:00am to 4:30pm).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Charles Bowers can be reached on 703-308-2417. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.



Tuan H. Nguyen  
Primary Examiner

SWS  
December 6, 2000